Model SM-5228

VACUUM TUBE VOLTMETER

595-1984

OPERATION/SERVICE MANUAL

NEW ENGLAND TRADE INSTITUTE
750 MASSABESIC ST
MANCHESTER, NEW HAMPSHIRE 03103

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VACUUM TUBE VOLTMETER

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INTRODUCTION

This Vaccum Tube Voltmeter is intended for use by servicemen, engineers, and maintenance men to make accurate measurements of DC+, DC-, and AC voltages, and resistance.

In this instrument, vacuum tubes are used for rectification and amplification on all measurement functions to insure good sensitivity and stability of operation. Precision resistors are used in the voltage divider networks to provide high accuracy.

The confusing tangle of test leads coming from the front panel of most VTVMs is eliminated by the use of a combination AC-OHMS/DC switching test probe and a single jack input connection for both the test probe and ground leads. The 1 megohm resistor in the probe is switched into operation when the probe switch is set on DC. This isolating resistor allows DC voltages to be measured without materially affecting AC voltages present at the test point.

Because the VTVM has a very high input impedance, the circuit in which the voltage is being measured will not be significantly loaded by the VTVM. Most nonelectronic voltmeters (VOM) have a much lower input impedance over the most frequently used ranges of test voltages. Consequently, when a VOM is used to measure voltages in high impedance circuits, the indicated voltage will be appreciably less than the actual voltage. The amplifier section enables the VTVM to accurately measure much higher resistances than can be conveniently measured with a VOM.

HIGH VOLTAGE TEST PROBE

A high voltage test probe is available. This probe will permit VTVM DC measurements up to 30,000 volts, which covers the range of flyback power supply voltages commonly encountered in TV receivers. This probe consists of a red molded housing with a black molded handle. It contains a 2% precision 1090 megohm resistor and provides a DC range multiplication factor of 100 for 11 megohm input VTVMs.

RF TEST PROBE

An RF test probe is available. This probe will permit VTVM usage for RF measurements up to 90 volts; its response is substantially flat from 1000 Hz to 100 MHz. A built-in isolating capacitor permits measurement of RF voltages superimposed on DC potentials of up to 1000 volts.

SPECIFICATIONS

Electronic DC Voltmeter –	
7 Ranges	0-1.5, 5, 15, 50, 150, 500, 1500 volts full scale; up to 30,000 volts with accessory probe.
Input Resistance	11 megohm (1 megohm in probe) on all ranges; 1100 megohms with accessory probe.
Circuit	Balanced bridge (push-pull) using twin triode.
Accuracy	±3% of full scale.
Electronic AC Voltmeter –	
7 Ranges	0-1.5, 5, 15, 50, 150, 500, 1500 rms scales (.353 of peak-to-peak).
Frequency Response (5 V range)	±1 dB 25 Hz to 1 MHz (600 Ω source, referred to 60 cps).
Circuit	Half-wave voltage doubler, using twin diode.
Accuracy	±5% of full scale.
Input Resistance And Capacitance	1 megohm shunted by 40 pF measured at input terminals (200 pF at probe tip).
Electronic Ohmmeter –	
7 Ranges	Scale with 10 Ω center X1, X10, X100, X1000, X10K, X100K, X1MEG. Measures .1 Ω to 1000 megohms with internal battery.
Meter	6", 200 μA movement, polystyrene case.
Probe	Combined AC-OHMS/DC switching probe, single jack input for probe and ground connections.
Dividers	1% precision type.
Tubes-Diode	1 - 12AU7, twin triode meter bridge. 1 - 6AL5, twin diode AC rectifier. 1 - Silicon diode power supply rectifier.
Battery	1-1/2 volt, "C" cell.
Power Requirements	105-125 or 210-250 volts, 50/60 Hz AC, 10 watts.
Cabinet Size	5" high x 12.68" wide x 4.75" deep (overall). (12.7 cm high x 32.2 cm wide x 12.1 cm deep.)
Net Weight	5 lbs. (2.27 kgs.)

OPERATION

210-260 VOLT PRIMARY WIRING

When shipped, this instrument is ready for operation from a 105-130 volt AC source. If 210-260 volt AC operation is desired, remove the instrument cover and perform the following instructions:

1. Refer to Figure 1A and remove the black-green wire from lug 1 of terminal strip B.

2. Remove the black-yellow wire from lug 1 of terminal strip E.

3. Connect both the black-green wire and black-yellow wire to lug 1 of terminal strip D as shown in Figure 1B.

4. Reinstall the cover.

NOTE: Electrical regulations in some areas require a special line cord and/or plug for 240-volt operation. Replace if necessary.

BATTERY INSTALLATION

The OHMS function of this instrument requires a 1.5-volt C-size battery for operation. It is easily installed by removing the instrument cover and snapping into position in its holder. Be sure the positive (+) end of the battery is inserted into the metal cup and the negative (—) end is held by the spring.

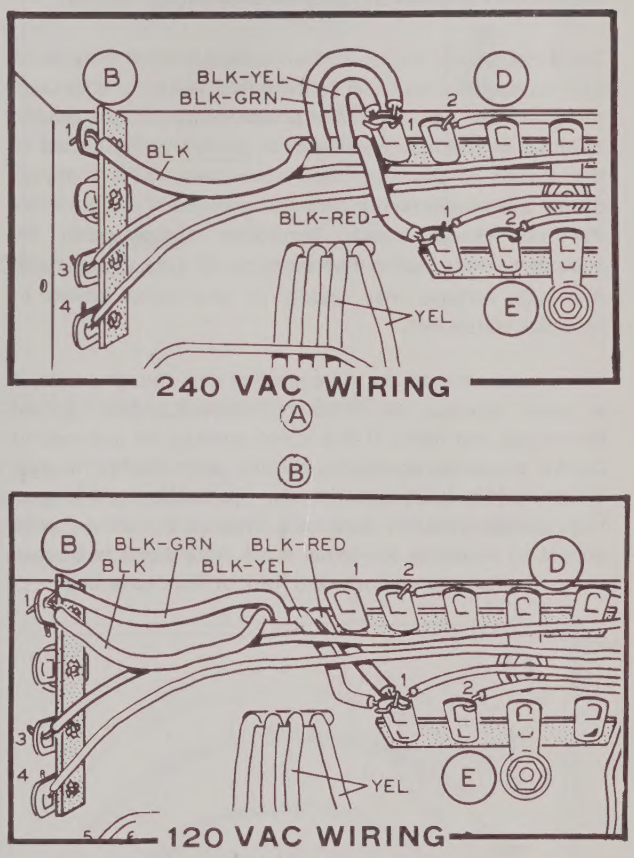


Figure 1

SAFETY PRECAUTIONS

CAUTION: It is good practice to observe certain basic rules of operating procedure anytime voltage measurements are to be made. Always handle the test probe by the insulated housing only and do not touch the exposed tip portion.

The metal case of this instrument is connected to the ground of the internal circuit and to the power line ground through the green line cord wire. For proper operation, the ground terminal of the instrument should always be connected to the ground of the equipment under test. There is always danger inherent in testing electrical equipment and therefore the user should clearly familiarize himself with the equipment under test before working on it, bearing in mind that high voltages may appear at unexpected points in defective equipment.

When measurements are to be made at high voltage points, it is good practice to remove operating power before connecting test leads. If this is not possible, be particularly careful to avoid accidental contact with nearby objects which could provide a ground return path. When working on high voltage circuits, play safe. Keep one hand in your pocket to minimize accidental shock hazard and to be sure to stand on a properly insulated floor or floor covering.

COMBINATION PROBE

The combination AC-OHMS/DC test probe eliminates two of the usual three test jack installations in the VTVM front panel. The probe should be set to AC-OHMS (the position opposite the DC marking) when the Function switch is on AC or OHMS, and should be set to DC when the Function switch is on DC+ or DC-. The probe can be clipped onto any lead in the circuit, as shown in Figure 2, giving the operator another free hand.

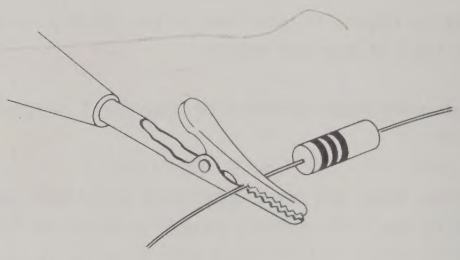


Figure 2

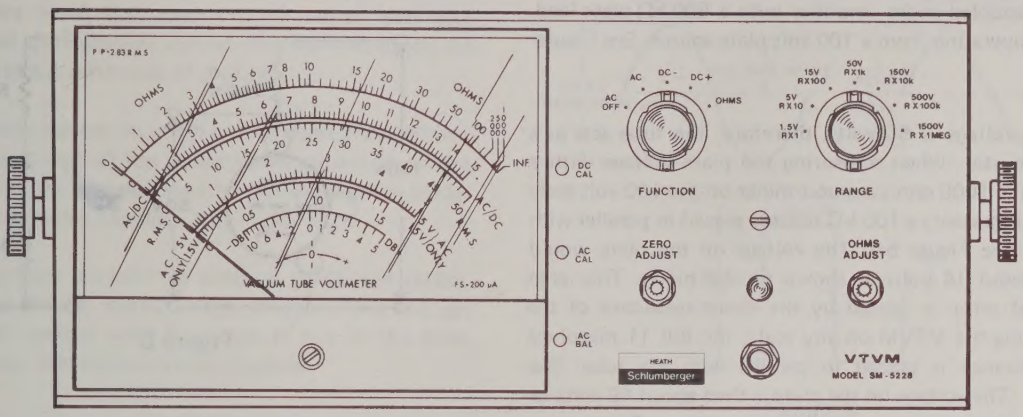


Figure 3

READING THE METER

The voltage markings on the Range switch refer to the full scale reading. For DC measurements the scale is marked 0-15 and 0-50 for voltage. This scale is also used on AC except for the 1.5 V and 5 V ranges. For 1.5 volts DC read the 15 V scale and move the decimal one place to the left. For example, a reading of 8 would be .8 volt. For 5 volts DC read the 50 V scale. For example, a reading of 40 would be 4 volts. On the 15 V range, read the 0-15 V scale directly. On the 50 range, read the 0-50 V scale directly. On the 150 V range, read the 0-15 V scale and move the decimal one place to the right. For example, a reading of 13 would be 130 volts. On the 500 V range, read the 50 V scale and move the decimal point one place to the right. For example, a reading of 40 would be 400 volts. When using a 1500 V range, use the 15 V scale and move the decimal two places to the right. For example, a reading of 12 would be 1200 volts.

When measuring up to 1.5 volts AC, read the 1.5 V AC ONLY range directly; this scale is lettered in red. On the 5V range, use the 5 V AC ONLY scale and read it directly. This scale is also lettered in red.

Resistance measurements are read on the top scale which is lettered in green. The marking RX1 V indicates that you should read the scale on the Range switch directly. For RX100, add two zeros to the reading. For RX10K, add four zeros and on RX1MEG add six zeros or read the scale directly in megohms.

CENTER SCALE "0" POSITION

Your VTVM features a convenient center scale zero position. The adjustment range of the panel ZERO ADJ control will permit center scale zero deflection of the meter pointer. See Figure 4.

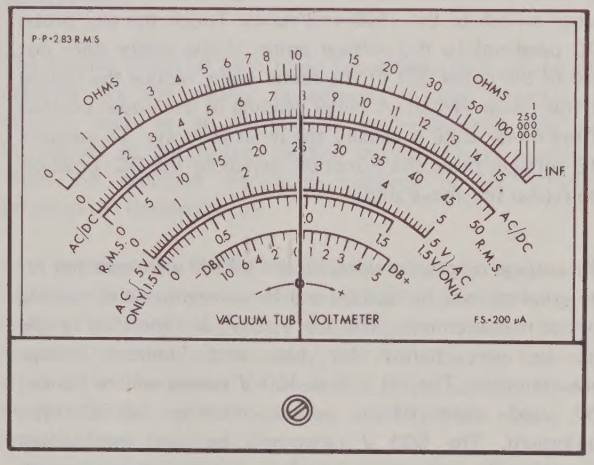


Figure 4

DC VOLTAGE MEASUREMENTS

The vacuum tube voltmeter has many advantages over the nonelectronic voltmeter. The largest advantage is its ability to measure voltages without significantly loading the circuitry. This characteristic enables the voltage to be measured more accurately. This is desirable, especially in high impedance circuits such as oscillator grid circuits, resistance coupled amplifiers, and AVC networks.

To illustrate the advantages of the VTVM, assume that a resistance coupled audio amplifier with a 500 kΩ plate load resistor is operating from a 100 volt plate source. See Figure 5.

The plate voltage is 50 volts, therefore, the tube acts as a 500 kΩ resistor. When measuring the plate voltage with a conventional 1000 ohms-per-volt meter on the 100 volt scale the meter represents a 100 kΩ resistor placed in parallel with the tube. See Figure 5A. The voltage on the plate would then be about 14 volts as shown on the meter. This large amount of error is caused by the shunt resistance of the meter. Using the VTVM on any scale, the full 11 megohms input resistance is placed in parallel with the tube. See Figure 5B. The voltage on the plate is then about 49 volts or 2% lower than the normal operating voltage. Thus, more accurate readings can be obtained only with the high resistance provided by an electronic voltmeter.

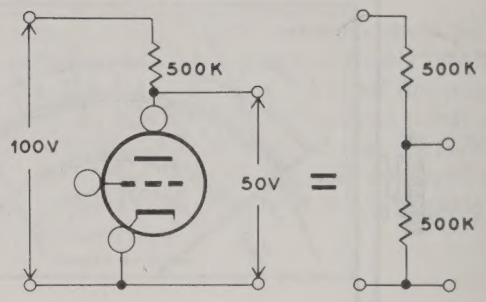


Figure 5

To measure +DC voltages, connect the common (black) test lead to the "cold" (common) side of the voltage. In transformer operated equipment, common is usually the chassis.

Set the Range switch to the range which will handle the voltage to be measured. If the voltage is unknown, set the Range switch to the 1500 volt range. Touch the test probe (DC position) to the voltage point. If the meter does not read in the upper 2/3 of the meter scale, reduce the setting of the Range switch. A meter reading in the upper portion of the meter scale is usually the most accurate. To measure -DC voltages place the Function switch to the DC- position and repeat the above steps.

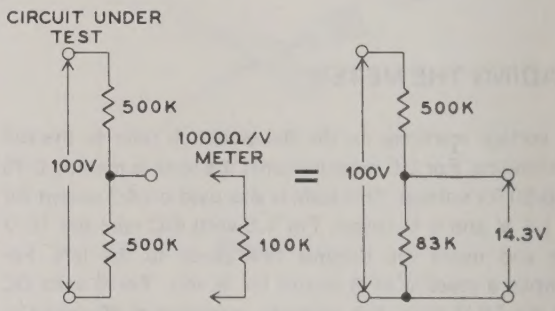


Figure 5A

The voltage ranges provided by the VTVM were selected for the greatest ease in reading and for convenience in making voltage measurements. The 1.5 V, 5 V, and the 15 V ranges will be very handy for bias and filament voltage measurements. The 50 V and 150 V ranges will be handy, and used most often, when checking AC-DC type equipment. The 500 V range will be used most when measuring B+ voltages in transformer operated equipment.

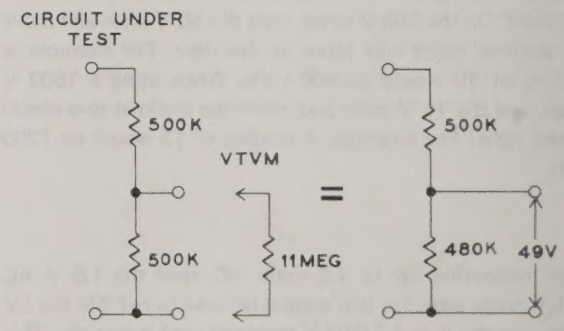


Figure 5B

AC VOLTAGE MEASUREMENTS

WARNING: When your power line outlet is the 3-wire, polarized type, DO NOT use the common (negative) lead of this VTVM to measure power line voltages. To do so may short circuit the power line through the common lead, the chassis, and the green line cord wire.

Power Line Measurements

1. Set the Function switch to AC, the Range switch to 150 V, and the meter probe to AC.

2. Move the meter common lead out of the way, as it will not be used.

3. Touch the meter probe to one side of the power line. If there is no indication on the meter, you have selected the common side of the AC line; touch the probe to the other side of the line.

4. To obtain contact to a wall outlet, insert a screwdriver blade into one of the outlet openings and touch the probe to the exposed part of the screwdriver blade. Try both outlet openings. BE CAREFUL.

5. If you have occasion to measure a 240 volt outlet, such as for an electric range or dryer, you will get voltage readings with the probe at two of the three openings. Add these readings together.

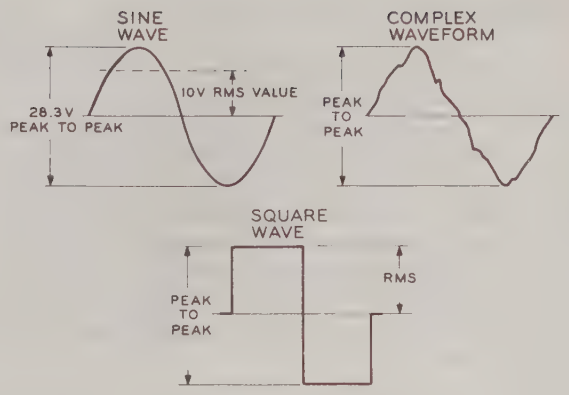


Figure 6

Other AC Voltage Measurements

To measure AC voltage with the VTVM, connect the common (black) lead to the common or "cold" side of the voltage to be measured. Set the Function switch to AC and set the Range switch to a range greater than the voltage to be measured, if known. If unknown, set it to 1500 V. With the test probe in the AC position, touch the point in the circuit at which the voltage is to be measured. If the meter moves less than 1/3 of full scale, switch to the next lower range. The maximum AC voltage that can be safely measured with your VTVM is 1500 volts, and this limit must not be exceeded except with the high-voltage probe. The meter scale of the VTVM is calibrated in rms.

AC voltage readings are obtained by rectifying the AC voltage and applying the resulting DC voltage to the VTVM circuitry. The rectifier circuit is a half-wave doubler and the DC output is proportional to the peak-to-peak value of the applied AC.

For sine wave voltages, the rms value is .35 times the peak-to-peak value. For complex waveforms this ratio does not necessarily hold true, and may vary from practically zero for thin spikes to .5 for square waves. See Figure 6.

For sine wave voltages over 5 volts, the rms value is read on the same scale as a DC voltage. When using the 1.5 volt and 5 volt ranges, the 1.5 and 5 volt AC scales should be read.

When connecting the VTVM to the circuit under test, the VTVM input resistance R and input capacitance C are effectively placed in parallel with the voltage source. This may change the actual voltage to be measured through loading.

At low frequencies, such as the power line frequencies of 50 or 60 cps, the effects of capacitance loading may usually be disregarded and thus the loading by the VTVM may be considered the same as connecting a 1 megohm resistor across the voltage source.

At higher frequencies, the capacitor reactance decreases. At 10 kc for example, it is approximately 170 kΩ. Such a value may seriously affect the voltage at the point of measurement.

The loading effect of both input capacitance and resistance depends on the source impedance. In low impedance circuits, such as 50 to 600 Ω, no noticeable error is introduced in the voltage reading through circuit loading. Then the specified frequency response of the VTVM becomes the limiting factor.

As a general rule, it should be kept in mind that frequency response and loading may affect the accuracy of the voltage reading obtained. Consider the resistive loading of 1 megohm regardless of frequency, and the capacitive loading effect at the frequency involved. The actual capacitance of the instrument and the leads may also affect the tuning of low capacitance resonant circuits.

Knowledge of the values in the circuit under test and the values of the input R and C of the VTVM will permit valid readings to be obtained for a wide range of impedances within the full frequency response of the instrument.

The VTVM is a sensitive electronic AC voltmeter and, as the human body picks up AC when near any AC wires, the meter will indicate this pickup. Never touch the probe when on the lower AC ranges. Zero should be set with the probe shorted to the common clip.

RESISTANCE MEASUREMENTS

To measure resistance with the VTVM, connect the common (black) lead to one side of the resistor or circuit to be measured. Set the Function switch to OHMS and set the Range switch to such a range that the reading will fall as near mid-scale as possible. Set the OHMS ADJ control so the meter indicates exactly full scale (infinity on ohms scale) with the test lead (AC position) not connected to a resistor or circuit. Then touch the test prod to the other side of the resistor or circuit to be measured. Read resistance on OHMS scale and multiply by the proper factor as shown on the Range switch settings.

NOTE: Although a battery is used to measure resistance, the indication is obtained through the electronic meter circuit and therefore the VTVM must be connected to the AC power line and turned on. Establish the habit of never leaving the instrument set in the OHMS position as this could greatly shorten the life of the ohmmeter battery, particularly if the test leads are accidentally shorted together when lying on the service bench.

DECIBEL SCALE

The human ear does not respond to the volume of sound in proportion to voltage or power level, therefore, a unit of measure called the "bel" was adopted. The "bel" is more nearly equivalent to human hearing ratios. Normally the reading is given in 1/10 of a "bel" or a "decibel" (dB). Different reference points for "0 dB" have been adopted for various purposes. The trend in recent years is to use 1 milliwatt in a 600 Ω load as the 0 dB reference, particularly for audio work. This is equal to .774 volt.

On the VTVM, the meter pointer position that corresponds to 0 dB is 7.74 on the 0-15 scale. Due to the special calibration used on the 1.5 V and 5 V AC scales, slight inaccuracies will be introduced into the dB reading when making decibel measurements with the Range switch in the 1.5 V and 5 V positions.

The resistance values of the voltage divider were chosen so that each progressive setting of the Range switch represents a change of 10 dB. For example, if the signal voltage at the input of an amplifier reads 0 dB in the 1.5 volt position and the output voltage reads 0 dB in the 15 volt position, it would indicate that the amplifier has a gain of 20 dB.

Since the decibel is a current, voltage, or power ratio, it may be used as such without specifying the reference level. A fidelity curve may be run on an amplifier by feeding in a signal of variable frequency but constant amplitude. At a reference frequency of 400 cps adjust the input voltage for a convenient indication, 0 dB for instance, on the VTVM connected to the output. As the input frequency is varied, the output variation may be noted directly in dB above and below the specified reference level.

ACCURACY

The accuracy of the meter movement is within 2% of full scale which means that on the 1500 V range, for instance, the accuracy of the movement will be within 30 volts at any point on the scale. On DC, the accuracy of the multipliers, 1%, may be additive, resulting in an accuracy of within 3% of full scale.

On AC, the accuracy of the rectifier circuit contributes variations which result in an accuracy of within 5% of full scale.

The accuracy on the OHMS range depends on the meter accuracy, the ohms multiplier accuracy (including the internal resistance of the battery) and the stability of the battery voltage. On the RX1 scale, the internal resistance of the battery and the battery voltage both vary as a result of the current drawn by the resistance under test. For greatest accuracy, tests on low resistance values should be made as quickly as possible. On the higher ohms range, the accuracy depends practically on the multipliers which are 1% and the meter movement accuracy, 2%. Because of the nonlinear OHMS scale, the resulting accuracy is not readily expressed in a percentage figure, but greatest accuracy is obtained at mid-scale readings.

NOTE: When comparing this instrument with another VTVM, consider that the accuracy of the other instrument may deviate in the opposite direction. Therefore, when comparing two instruments of 5% accuracy, the total difference may be 10%. Critical comparisons should only be made against certified laboratory standards.

MAINTENANCE

METER

Because of the delicate nature of the meter movement, no attempt should be made to repair the meter. Such attempts would automatically void the standard warranty coverage of the meter itself.

ELECTROSTATIC CHARGE

The polystyrene meter cover has been treated to resist an accumulation of static electricity. However, should a static charge accumulate thorugh repeated polishing or cleaning of the meter cover, the pointer will deflect in an erratic manner, regardless of whether the instrument is turned off or on. This condition can be corrected quickly. Apply a small quantity of liquid dishwashing detergent to a clean, soft cloth and wipe the surface of the meter cover. The accumulated electrostatic charge will immediately disappear. It is not necessary to remove the cover for this correction.

CHECKING METER COIL CONTINUITY

ALWAYS use a resistor of at least 10 kΩ in series with the meter movement and the ohmmeter test leads when checking for meter coil continuity. If this resistor is not used to reduce the current, the meter movement will probably be seriously damaged.

TEST LEADS

Because of their constant flexing during use, the test leads are not above suspicion, especially when the VTVM has been in use for several years. Erratic or improper DC voltage measurements can sometimes be caused by a fault in the shielded test lead or in the connection of the 1 megohm isolating resistor used in the test probe.

CIRCUIT DESCRIPTION

In order to obtain a better understanding of the circuit, follow the Schematic Diagram (fold-out from Page 15) while reading the Circuit Description.

The combination AC-OHMS/DC test lead of the VTVM is connected to the Function switch, which is used to connect the part of the circuit needed for any of the VTVM measurement functions. The COMMON test lead is connected to the case (ground) of the instrument.

With the Function switch in the DC+ or DC– position and the switching probe on DC, the test voltage is applied through 1 megohm resistor R1 in the probe to the Range switch, on which is a series of precision resistors, R17 through R23, arranged as a voltage divider. Depending on the position of the Range switch, a portion of this DC voltage is "picked off' and applied through resistor R12 to the input grid of the 12AU7 tube.

With the Function switch in the AC position and the test probe on AC-OHMS, an AC test voltage is applied through capacitors C1 and C2 to the 6AL5 tube (half-wave doubler circuit) where it is changed to a DC voltage which is proportional to the peak-to-peak value of the applied AC test voltage. On the higher AC ranges, a voltage divider arrangement consisting of R2, R3, and R4, is used at the input of the 6AL5 tube to insure that the AC voltage applied to the 6AL5 tube does not exceed the tube's rating. The DC voltage output of the 6AL5 tube is applied to the Range switch and then to the input grid of the 12AU7 tube, in the same way that DC test voltages are applied. The VTVM responds to peak-to-peak voltage regardless of the test voltage waveform. The AC balance control is used to "buck-out" the small amount of contact potential in the 6AL5 tube, thus eliminating residual readings on the lower AC ranges.

The ohmmeter section of the VTVM uses a 1.5 volt battery connected in series with part of the standard-resistor network (determined by the Range switch position) and the resistance to be measured. The ratio between the ohmmeter standard-resistor network and the measured resistance determines what portion of the ohmmeter battery voltage is applied to the input grid of the 12AU7 tube.

Thus, for all measurement functions, a voltage dependent upon the quantity being measured is applied to the grid of one-half of the 12AU7 twin triode. With zero voltage input to the 12AU7 balanced bridge circuit, each of its triode

sections draws the same amount of cathode current and therefore each cathode is at the same voltage potential. The meter movement is connected between the cathodes of the 12AU7 tube and consequently will not deflect since both cathodes are at the same potential.

When a positive voltage (from the Range switch) is applied to one-half of the 12AU7 tube, this half of the tube draws more current than the other half, causing a difference in cathode potential between the two tube sections. Since the meter is connected between the two cathodes, a current flows through the meter movement. The meter pointer responds proportionally to this current, indicating the value of voltage or resistance being measured. The DC+ and DC- switch positions are used to reverse the meter connections between the cathodes so that current always flows through the meter in the same direction.

The use of the bridge circuit minimizes any change in the voltage reading if the B+ voltage in the VTVM should vary since the resulting variation in tube conduction will occur in both triodes and, therefore, will not affect the difference in cathode potential. Also, the maximum conduction characteristics of the 12AU7 tube, as used in the VTVM circuit, are such that the voltage applied to the meter terminals cannot be large enough to damage the meter movement. This is one of the primary advantages of the VTVM circuit. The meter movement cannot be burned out by inadvertently measuring a voltage that is higher than the Range switch setting. However, if excessive voltage is applied, the pointer may be bent as it hits against the stop. Caution must also be exercised to avoid applying any test voltage to the test probe when the Function switch is set in the OHMS position. The precision resistors in the ohmmeter voltage divider network can easily be burned in this way.

The power supply of the VTVM uses a silicon diode in a half-wave rectifier circuit. An electrolytic capacitor is used for filtering the DC voltage from the power supply. The power supply provides both B+ voltage for the 12AU7 tube and positive DC "buck-out" voltage for the AC balance circuit.

RECALIBRATION

If your VTVM is wired for 240 VAC, read that figure instead of 120 VAC in the following instructions.

Make sure that the mechanical zero position of the meter pointer is correct. If not, adjust as follows:

1. Turn the plastic screw on the meter face with a screwdriver while gently tapping the meter face with one finger until the pointer coincides with the zero line on the left side of the scale. Turn the instrument ON and allow it to warm up for 30 minutes.

ZERO ADJUST

1. Set the Function switch to DC+.

2. Check operation of the ZERO ADJ control. Turning this control should move the meter pointer part way up scale. Set the pointer to zero at the left side of the scale and check for zero positioning when the Function switch is changed to DC-. It should be possible to obtain a ZERO ADJ control position that will permit the meter pointer to remain stationary when switching from DC+ to DC-.

DC CALIBRATE

1. Insert the test lead phone plug.

2. Set the Function switch to DC+, the Range switch to 1.5 V, and the probe to DC.

3. Connect the probe and common test leads to a fresh flashlight battery or an accurate 1.55-volt DC source, and adjust the DC Calibrate control so that the meter pointer falls directly over the very small red dot on the meter face. Approach the red dot going up scale by turning the screwdriver control and watch the meter read 1.4 volts, and 1.5 volts, and then the red dot. As soon as the red dot is reached, stop turning the DC Calibrate control. Remember that the Range switch must be set on 1.5 V for this adjustment.

AC CALIBRATE

NOTE: Your AC power line outlets may be either the 2-wire or 3-wire types. Determine which type you have and complete the appropriate AC Calibration instructions. Use the AC Calibrate With Line Cord Adapter for the 2-wire

outlets and AC Calibrate Without Line Cord Adapter for the 3-wire outlets.

AC Calibrate With Line Cord Adapter

1. Install the line cord adapter on the line cord.
2. Temporarily remove the phone plug from the jack.
3. Set the Range switch to 1.5 V and the Function switch to AC.
4. Adjust the AC Balance control so no movement is detected when switching from AC through DC- to DC+.
5. Set the Range switch to the 150 V range if you wired your VTVM for 120 VAC operation, or to the 500 V range if you wired the VTVM for 240 VAC operation.
6. Set the Function switch to AC.
7. Set the AC Calibrate control fully clockwise.
8. Reinsert the phone plug.
9. Set the switch on the test probe to AC.
10. Connect the test probe to one side of the AC line and then the other side. Note the lowest reading and remove the probe from the AC line.
11. Now connect the negative meter lead to the side of the AC line with the lowest reading. Then connect the test probe to the other side of the line.
12. Adjust the AC Calibrate control until the meter pointer indicates the line voltage.
13. Disconnect the test lead and probe.

AC Calibrate Without Line Cord Adapter

WARNING: When your power line outlet is the 3-wire, polarized type, DO NOT use the common (negative) lead of this VTVM to measure power line voltages. To do so may short circuit the power line through the common lead, the chassis, and the green line cord wire.

1. Temporarily remove the phone plug from the jack.
2. Set the Range switch to 1.5 V and the Function switch to AC.
3. Adjust the AC Balance control so no movement is detected when switching from AC through DC- to DC+.
4. Set the Range switch to the 150 V range if your VTVM is wired for 120 VAC operation, or to the 500 V range if wired for 240 VAC operation.
5. Set the Function switch to AC.
6. Set the switch on the test probe to AC.
7. Reinsert the phone plug.
8. Connect the test probe to the side of the AC line with the highest reading.
9. Adjust the AC Calibrate control until the meter pointer indicates the line voltage.

PARTS LIST

The key numbers relate to the Schematic.

RESISTORS

(All resistors are 10%, 1/2-watt unless otherwise specified.)

KEY No.	PART No.	DESCRIPTION
R1	1-35	1 MΩ
R2	1-27	150 kΩ
R3	2-138	400 kΩ, 1%
R4	2-123	800 kΩ, 1%
R5	1-27	150 kΩ
R6	1-70	22 MΩ
R7	1-70	22 MΩ
R8	1-70	22 MΩ
R9	1-70	22 MΩ
R10	1-70	22 MΩ
R11	1-70	22 MΩ
R12	1-38	3.3 MΩ
R13	10-142	10 kΩ control
R14	10-57	10 kΩ control
R15	10-57	10 kΩ control
R16	1-40	10 MΩ
R17	2-147	6.838 MΩ, 1%
R18	2-146	2.162 MΩ, 1%
R19	2-45	683.8 kΩ, 1%
R20	2-42	216.2 kΩ, 1%
R21	2-40	68.38 kΩ, 1%
R22	2-39	21.62 kΩ, 1%
R23	2-50	10 kΩ, 1%
R24	2-52	9 MΩ, 1%
R25	2-51	900 kΩ, 1%
R26	2-41	90 kΩ, 1%
R27	2-35	9000 Ω, 1%

KEY No.	PART No.	DESCRIPTION
Resistors (cont'd.)		
R28	2-29	900 Ω, 1%
R29	2-24	90 Ω, 1%
R30	3-4-2	9.1 Ω, 1%, 2-watt
R31	1-126	180 kΩ
R32	1-27	150 kΩ
R33	10-142	10 kΩ control
R34	1-27	150 kΩ
R35	1-23	27 kΩ
R36	1-3	100 Ω
R37	10-57	10 kΩ control
R38	1-20	10 kΩ

CAPACITORS

C1	23-19	0.047 μF paper
C2	23-61	0.05 μF paper
C3	23-61	0.05 μF paper
C4	21-27	0.005 μF ceramic
C5	21-27	0.005 μF ceramic
C6	25-19	20 μF electrolytic

GENERAL COMPONENTS

D1	57-27	1N2071
M	407-732	Meter
T1	54-2-24	Power transformer
V1	411-40	6AL5 tube
V2	411-275	12AU7 tube
	63-501	Function switch
	63-500	Range switch
	412-36	Neon lamp

FACTORY REPAIR SERVICE

You can return your completed kit to the Heath Company Service Department to have it repaired for a minimum service fee. (Kits that have been modified will not be accepted for repair.) Or, if you wish, you can deliver your kit to a nearby Heathkit Electronic Center. These centers are listed in your Heathkit catalog.

To be eligible for replacement parts under the terms of the warranty, equipment returned for factory repair service, or delivered to a Heathkit Electronic Center, must be accompanied by the invoice or the sales slip, or a copy of either. If you send the original invoice or sales slip, it will be returned to you.

If it is not convenient to deliver your kit to a Heathkit Electronic Center, please ship it to the factory at Benton Harbor, Michigan and observe the following shipping instructions:

Prepare a letter in duplicate, containing the following information:

- Your name and return address.
- Date of purchase.
- A brief description of the difficulty.
- The invoice or sales slip, or a copy of either.
- Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the warranty.

Attach the envelope containing one copy of this letter directly to the unit before packaging, so that we do not overlook this important information. Send the second copy of the letter by separate mail to Heath Company, Attention: Service Department, Benton Harbor, Michigan 49022.

Check the equipment to see that all parts and screws are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least THREE INCHES of resilient packing material (shredded paper, excelsior, etc.) on all sides, between the equipment and the carton. Seal the carton with gummed paper tape, and tie it with a strong cord. Ship it by prepaid express, United Parcel Service, or insured parcel post to:

Heath Company
Service Department
Benton Harbor, Michigan 49022

PART No.	PRICE Each	DESCRIPTION

PROBE PARTS

A factory-wired and tested replacement probe assembly Model PKW-4, is available from Heath Company at $4.95 plus postage. Due to the cost of handling, the replacement probe assembly is not available in kit form.

WIRE-SLEEVING

340-2	.05/ft	Bare wire
341-1	.05/ft	Black test lead
343-11-1	.20	4 foot shielded test lead
344-59	.05/ft	Hookup wire
346-1	.05/ft	Sleeving

METAL PARTS

90-262-2	1.50	Cabinet
200-524	.60	Chassis
203-351-2	1.40	Front panel
204-254	.15	Battery bracket
204-542-2	1.25	Gimbal bracket
214-2	.15	Battery housing cup
258-7	.10	Battery spring

HARDWARE

250-49	.05	3-48 x 1/4" screw
250-116	.05	6-32 x 1/4" screw (black)
250-89	.05	6-32 x 3/8" screw
250-54	.05	10-32 x 5/8" screw
250-155	.05	#6 sheet metal screw (black)
250-68	.05	#7 x 3/4" wood screw
252-1	.05	3-48 nut
252-3	.05	6-32 nut
252-7	.05	Control nut
252-32	.05	Push-on speednut
252-49	.30	Thumbnut
253-2	.05	#6 fiber shoulder washer
253-10	.05	Control flat washer

PART No.	PRICE Each	DESCRIPTION

Hardware (cont'd.)

253-19	.05	#10 flat washer
254-7	.05	#3 lockwasher
254-1	.05	#6 lockwasher
254-4	.05	Control lockwasher
255-44	.10	Threaded spacer
259-1	.05	#6 solder lug

MISCELLANEOUS

54-2-24	3.10	Power transformer
75-30	.10	Strain relief, round cord
75-71	.10	Strain relief, flat cord
89-23	.75	Line cord
260-1	.10	Alligator clip
260-51	.20	Alligator clip, threaded
261-29	.05	Plastic foot
331-6	.15	Solder
407-75	12.10	Meter
413-11	.10	Neon lamp lens
455-50	.10	Knob bushing
490-5	.10	Nut starter
462-245	.25	Knob
	2.00	Manual (See front cover for part number.)

The above prices apply only on purchases from the Heath Company where shipment is to a U.S.A. destination. Add 10% (minimum 25 cents) to the price when ordering from a Heathkit Electronic Center to cover local sales tax .postage and handling. Outside the U.S.A. parts and service are available from your local Heathkit source and will reflect additional transportation, taxes, duties and rates of exchange.

To order parts, use the Parts Order Form furnished with this kit. If a Parts Order Form is not available, refer to Replacement Parts in the Kit Builders Guide.

DIFFICULTY	POSSIBLE CAUSE
Inaccurate DC readings.	1. Check the DC Calibrate control, R15. 2. Check the resistor in the test probe. Make sure that it is not being grounded. 3. Check the Range switch for proper assembly.
Ohms inoperative.	1. Check the OHMS ADJ control, R13 for the correct value. 2. Check the Range switch for proper assembly.
Ohms inaccurate.	1. Check the battery (substitution). 2. Check the value of all resistors on the Range switch which have a value beginning with the number "9". (The 9.1 Ω resistor, R30, should receive special attention.) NOTE: The ohms section of the VTVM is not intended for use as a standard. Where a great degree of accuracy is required, a bridge should be used.

MAINTENANCE

METER

Because of the delicate nature of the meter movement, no attempt should be made to repair the meter. Such attempts would automatically void the standard warranty coverage of the meter itself.

ELECTROSTATIC CHARGE

The polystyrene meter cover has been treated to resist an accumulation of static electricity. However, should a static charge accumulate through repeated polishing or cleaning of the meter cover, the pointer will deflect in an erratic manner, regardless of whether the instrument is turned off or on. This condition can be corrected quickly. Apply a small quantity of liquid dishwashing detergent to a clean, soft cloth and wipe the surface of the meter cover. The accumulated electrostatic charge will immediately disappear. It is not necessary to remove the cover for this correction.

CHECKING METER COIL CONTINUITY

ALWAYS use a resistor of at least 10 KΩ in series with the meter movement and the ohmmeter test leads when checking for meter coil continuity. If this resistor is not used to reduce the current, the meter movement will probably be seriously damaged.

TEST LEADS

Because of their constant flexing during use, the test leads are not above suspicion, especially when the VTVM has been in use for several years. Erratic or improper DC voltage measurements can sometimes be caused by a fault in the shielded test lead or in the connection of the 1 megohm isolating resistor used in the test probe.

ACCESSORY PROBES

HIGH VOLTAGE TEST PROBE

A high voltage test probe is available from the Heath Company. This probe will permit VTVM DC measurements up to 30,000 volts, which covers the range of flyback power supply voltages commonly encountered in TV receivers. This probe consists of a red molded housing with a black molded handle. It contains a 2% precision 1090 megohm resistor and provides a DC range multiplication factor of 100 for 11 megohm input VTVMs.

RF TEST PROBE

An RF test probe is available from the Heath Company. This probe will permit VTVM usage for RF measurements up to 30 volts; its response is substantially flat from 1000 cps to 100 mc. A built-in isolating capacitor permits a DC voltage range of up to 500 volts. It uses a printed circuit board for easy assembly and its housing is of polished aluminum with polystyrene insulation.

REPLACEMENT PARTS PRICE LIST

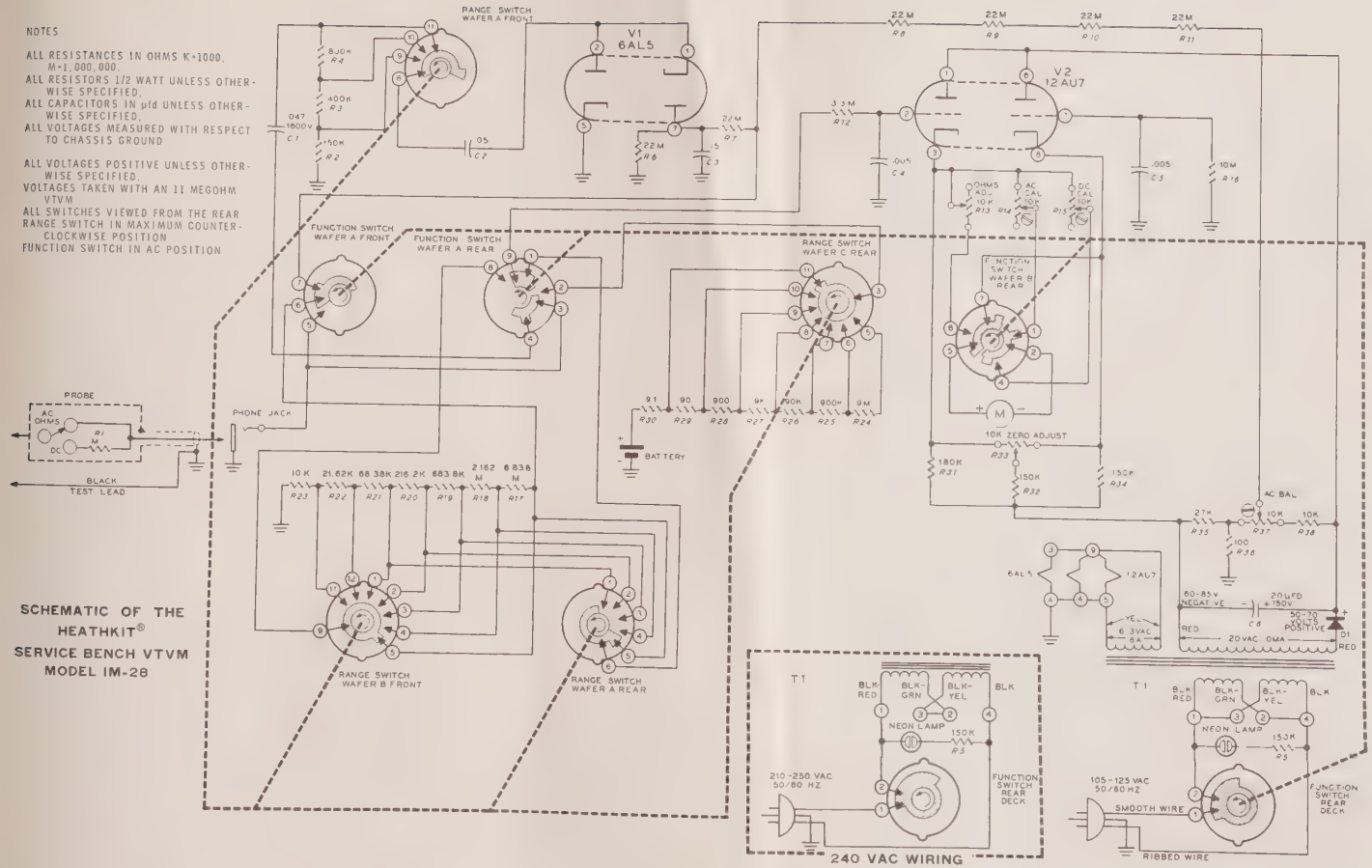
PART No.	PRICE Each	DESCRIPTION
RESISTORS		
1-3	.10	100 Ω 1/2 watt
1-20	.10	10 KΩ 1/2 watt
1-23	.10	27 KΩ 1/2 watt
1-27	.10	150 KΩ 1/2 watt
1-126	.10	180 KΩ 1/2 watt
1-35	.10	1 megohm 1/2 watt
1-38	.10	3.3 megohm 1/2 watt
1-40	.10	10 megohm 1/2 watt
1-70	.10	22 megohm 1/2 watt
2-24	.20	90 Ω 1/2 watt precision
2-29	.20	900 Ω 1/2 watt precision
2-35	.20	9 KΩ 1/2 watt precision
2-50	.20	10 KΩ 1/2 watt precision
2-39	.20	21.62 KΩ 1/2 watt precision
2-40	.20	68.38 KΩ 1/2 watt precision
2-41	.20	90 KΩ 1/2 watt precision
2-86	.20	150 KΩ 1/2 watt precision
2-42	.20	216.2 KΩ 1/2 watt precision
2-138	.20	400 KΩ 1/2 watt precision
2-45	.20	683.8 KΩ 1/2 watt precision
2-123	.25	800 KΩ 1/2 watt precision
2-51	.20	900 KΩ 1/2 watt precision
2-146	.20	2.162 megohm 1/2 watt precision
2-147	.50	6.838 megohm 1/2 watt precision
2-52	.30	9 megohm 1/2 watt precision
3-4-2	.25	9.1 Ω 2 watt precision

PART No.	PRICE Each	DESCRIPTION
CAPACITORS		
21-27	.10	.005 μfd disc ceramic
23-91	.50	.047 μfd 1600 V tubular
23-61	.20	.05 μfd 400 V tubular
25-19	.55	20 μfd 150 V electrolytic
CONTROLS-SWITCHES		
10-57	.35	10 KΩ tab-mounting control
10-142	1.10	10 KΩ vernier control
63-500	3.40	Range switch
63-501	2.80	Function switch
TUBES-LAMP-DIODE		
411-275	1.20	12AU7 tube
411-40	.90	6AL5 tube
412-36	.20	Neon lamp
57-27	.50	Silicon diode
TERMINAL STRIPS-SOCKETS-JACK-PLUG		
431-50	.10	1-lug terminal strip
431-5	.10	4-lug terminal strip
431-12	.10	4-lug terminal strip
431-40	.10	4-lug terminal strip
431-77	.10	5-lug terminal strip
434-15	.10	7-pin tube socket
434-16	.10	9-pin tube socket
436-20	.45	Phone jack
438-28	.65	Phone plug
432-27	.40	Line cord adapter

NOTES

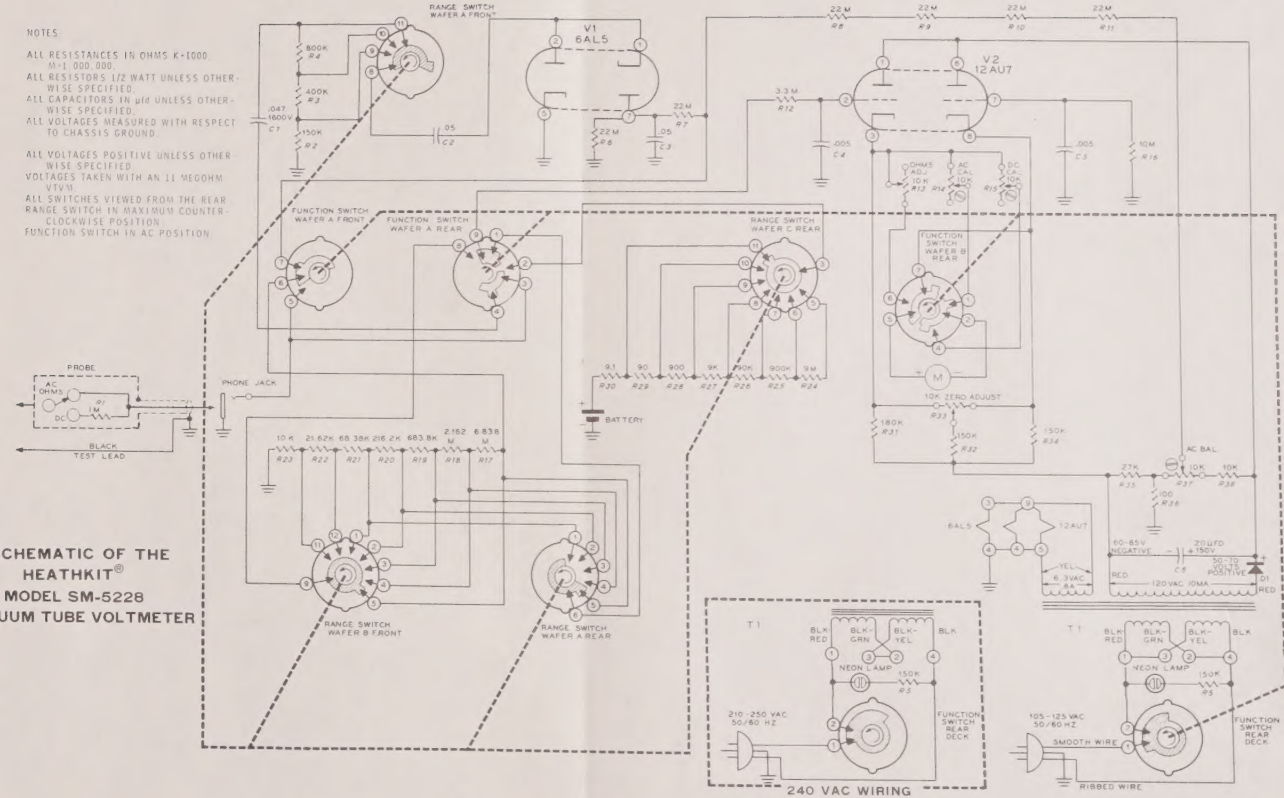
ALL RESISTANCES IN OHMS K=1000, M=1,000,000.
ALL RESISTORS 1/2 WATT UNLESS OTHERWISE SPECIFIED.
ALL CAPACITORS IN µfd UNLESS OTHERWISE SPECIFIED.
ALL VOLTAGES MEASURED WITH RESPECT TO CHASSIS GROUND

ALL VOLTAGES POSITIVE UNLESS OTHERWISE SPECIFIED.
VOLTAGES TAKEN WITH AN 11 MEGOHM VTVM
ALL SWITCHES VIEWED FROM THE REAR
RANGE SWITCH IN MAXIMUM COUNTER-CLOCKWISE POSITION
FUNCTION SWITCH IN AC POSITION



SCHEMATIC OF THE HEATHKIT® SERVICE BENCH VTVM MODEL IM-28

240 VAC WIRING



SCHEMATIC OF THE HEATHKIT® MODEL SM-5228 VACUUM TUBE VOLTMETER

SERVICE INFORMATION

The following Heath Company services are available if you need them: Replacement Parts, Technical Consultation, and Factory Service. Address all correspondence to:

HEATH COMPANY
Benton Harbor, Michigan 49022

For prompt service, use a separate letter for each department you write to.

Replacement parts and repair service are also available at your nearest Authorized Service Center or Heath Electronic Center. These Centers are listed in your Heath Catalog.

REPLACEMENT PARTS

If a replacement part is needed, please include the following information in your letter:

1. Part number and description.
2. Model Number and Series Number of the equipment.

If your equipment is in the Warranty period, add:

3. Date of purchase.
4. Nature of defect.

Heath Company will fill your order promptly. Please DO NOT RETURN PARTS unless they are requested. Parts that are damaged through carelessness or misuse by the customer will not be replaced without cost.

TECHNICAL CONSULTATION

You can write to our Technical Consultants for help with any Heath equipment, or for answers to any questions about the use of this equipment.

The completeness and accuracy of the advice mailed back to you depends entirely on the information in your letter. Be sure to include:

1. The Model Number and Series Number of the equipment (on blue and white identification label).
2. Date of purchase.
3. An exact description of the difficulty. Include switch positions, connections to other units, operating procedures, voltage reading, and any other information you think might be helpful.
4. List everything you have done in attempting to correct the difficulty.

FACTORY SERVICE

If you do not have qualified repair services at your disposal, you can return your equipment to the Heath Company Service Department to have it repaired for a minimum service fee. (Equipment that has been modified will not be accepted for repair.) Refer to Shipping Instructions for details on how to package and ship the equipment.

To be eligible for replacement parts under the terms of the Warranty, equipment returned for factory service must be accompanied by the invoice or the sales slip, or a copy of either. (If you send the original invoice or sales slip, it will be returned to you.)

SHIPPING INSTRUCTIONS

Check the equipment to see that all parts are in place. Then, wrap the equipment in heavy paper. Place the equipment in a strong carton, and put at least three inches of resilient packing material (shredded paper, excelsior, etc.) on all sides between the equipment and the carton.

Seal the carton with gummed paper tape and tie it with a strong cord. Ship it by prepaid Express or insured Parcel Post to:

HEATH COMPANY
Benton Harbor, Michigan 49022

Attach a letter, containing the following information to the outside of the carton:

1. Your name and return address.
2. Date of purchase.
3. A brief description of the difficulty.
4. Your authorization to ship the repaired unit back to you C.O.D. for the service and shipping charges, plus the cost of parts not covered by the Warranty.

YOUR HEATH FACTORY ASSEMBLED PRODUCT ONE-YEAR FULL WARRANTY

If you are not satisfied with our service - warranty or otherwise, or with our products, write directly to our Director of Customer Services, Heath Company, Benton Harbor, Michigan 49022. He will make certain your problems receive immediate, personal attention.

Our attorney insists that we describe our warranty using all the necessary legal phrases in order to comply with the new warranty regulations. Fine. Here they are:

For a period of one year after purchase, Heath Company will replace or repair free of charge any product that is defective either in materials or workmanship. We warrant that during the first full year after purchase, our products, when used in accordance with our printed instructions, will meet published specifications.

If your Heath factory-assembled product malfunctions or fails to operate at any time during the warranty period, through no fault of yours, we will service it free upon proof of purchase and delivery at your expense to the Heath factory, or any Heathkit Electronic Center (units of Schlumberger Products Corporation), or any of our authorized overseas distributors.

You will receive free consultation on any problem you might encounter in the use of your Heath product. Just drop us a line or give us a call. Sorry, we cannot accept collect calls.

Our warranty does not cover and we are not responsible for damage caused by misuse or fire or unauthorized modifications to or uses of our products for purposes other than advertised. Our warranty does not include reimbursement for customer assembly or set-up time.

This warranty covers only Heath factory assembled products and is not extended to allied equipment or components used in conjunction with these products. We are not responsible for incidental or consequential damages. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

HEATH COMPANY
BENTON HARBOR, MI. 49022

The Heath Company reserves the right to discontinue instruments and to change specifications at any time without incurring any obligation to incorporate new features in instruments previously sold.